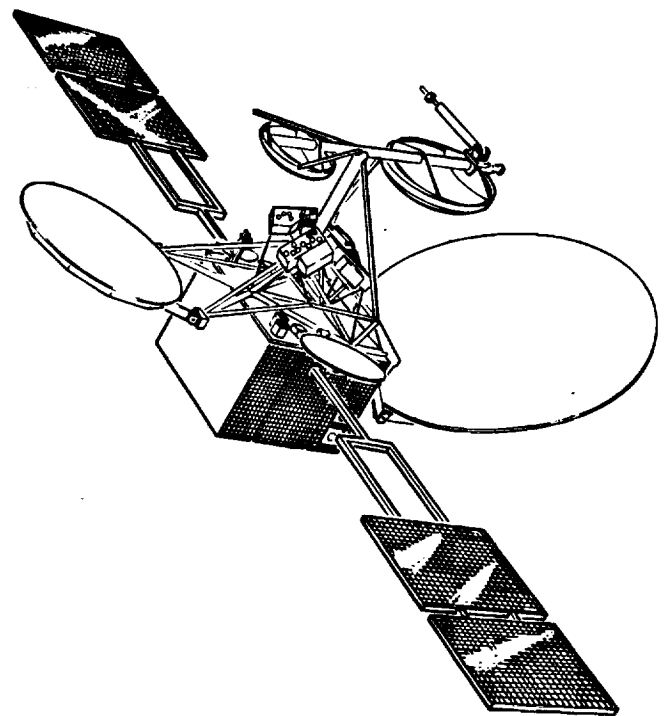


1N-6/
156316
P-48

Advanced Communications Technology Satellite High Burst Rate Link Evaluation Terminal Communication Protocol Software User's Guide Version 1.0

Richard C. Reinhart
Analex Corporation
Brook Park, Ohio



March 1993

Prepared for
Lewis Research Center
Under Contract NAS3-25776



(NASA-CR-189162) ADVANCED
COMMUNICATIONS TECHNOLOGY SATELLITE
HIGH BURST RATE LINK EVALUATION
TERMINAL COMMUNICATION PROTOCOL
SOFTWARE USER'S GUIDE, VERSION 1.0
Final Report (Analex Corp.) 48 p

N93-23134

Unclass

G3/61 0156316

**High Burst Rate Link Evaluation Terminal
Communication Protocol Software User's Guide**

Version 1.0, January 1993

Table of Contents

1.0	INTRODUCTION	1
1.1	Identification of Document	1
1.2	Scope of Document	1
1.3	Purpose and Objectives of Document	2
1.4	Document Status and Schedule	2
1.5	Document Organization	3
2.0	RELATED DOCUMENTATION	4
2.1	Parent Document	4
2.2	Applicable Documents	4
2.3	Information Documents	4
3.0	OVERVIEW OF PURPOSE AND FUNCTION	6
3.1	Protocol Software History and Overview	6
3.2	MCP and IFSM Command Files	6
3.3	Event and Telemetry Messages	7
3.4	Protocol Software Test Procedure	7
3.5	Restrictions and Limitations	8
4.0	INSTALLATION AND INITIALIZATION	9
4.1	Initiation Commands	9
4.2	Equipment Requirements and Set-up	10
4.3	MCP Command File Names	11
4.4	Loading System Programs and System Requirements	12
5.0	STARTUP AND TERMINATION	13
5.1	Pre-initialization Procedures	13
5.2	Start-up Commands	14
5.3	Normal Termination Procedure	14
5.4	Abnormal Termination Procedure	15
5.5	Abnormal Restart Procedure	15
6.0	FUNCTIONS AND THEIR OPERATIONS	16
6.1	MCP and IFSM Command Files	16
6.1.1	File Syntax	17
6.1.2	File Size	19
6.3	Sending MCP and IFSM Command Files to the CR&T	21
6.4	Protocol Software Monitor	23
6.5	Event Messages	24

7.0	ERROR MESSAGES AND RECOVERY PROCEDURES	25
7.1	MCP and IFSM Command File Syntax Errors	25
7.2	Protocol Errors	26
7.3	MCP Command Errors	27
7.4	Synchronization	28
8.0	ABBREVIATIONS AND ACRONYMS	29
9.0	GLOSSARY	31
10.0	APPENDICES	32
	Appendix A	32
	Common Menu Functions and Features	32
	Appendix B	34
	User's Terminal Definition	34
	Appendix C	35
	Event Messages	35
	Appendix D	39
	HBR-LET Control and Performance Monitor Software Problem Report	39
	Appendix E	41
	Concurrent 3205 Command Summary	41

**High Burst Rate Link Evaluation Terminal
Communication Protocol Software User's Guide**

Version 1.0, January 1993

List of Figures

Figure		Page
6-1	MCP Command File	17
6-2	IFSM Memory Load Command File	18
6-3	Protocol Software Monitor	23
7-1	MCP Command File with errors	25
7-2	Positive and Negative Event Messages	27
B-1	Output Terminal Port and Type Definition	34
D-1	HBR-LET Control and Performance Monitor Software Problem Report	40

List of Tables

Table		Page
6-1	MCP Command Protocol Filename Generation	20

High Burst Rate Link Evaluation Terminal Communication Protocol
Software User's Guide Version 1.0

Advanced Communications Technology Satellite

Richard C. Reinhart
Analex Corporation
3001 Aerospace Parkway
Brook Park, Ohio 44142-1003

1.0 INTRODUCTION

1.1 Identification of Document

This is the Communication Protocol Software User's Guide for the NASA Advanced Communications Technology Satellite (ACTS) High Burst Rate Link Evaluation Terminal (HBR-LET). This document complies with the NASA Software Management and Assurance Program (SMAP) guidelines in the Information System Life-Cycle and Documentation Standards, Release 4.3. This is one component of the Control and Performance Monitor (C&PM) subsystem document series.

1.2 Scope of Document

The Communication Protocol Software User's Guide contains all the information needed to load, initialize, and execute the Protocol Software on a Concurrent 3205 minicomputer. This document assumes the user is familiar with the Multibeam Communication Package (MCP) and Intermediate Frequency Switch Matrix (IFSM) commands used to control and configure the ACTS. These commands will not be discussed in this document in detail, although references are cited.

Users are not required to know the communication packet format used in the communication protocol. The Protocol Software will assemble all MCP and IFSM commands into the required format and transmit the packets to General Electric's (GE) Commanding, Ranging, and Telemetry Module (CR&T). Users must interpret event messages returned by the CR&T and take appropriate action when necessary. Event messages listed in the *CR&T/MCS Interface Specification* are reproduced in Appendix C of this document for easy reference.

Knowledge of the Concurrent computer user functions is required to create MCP and IFSM command files. Appendix E contains a summary of the user commands necessary to create and maintain user files. Refer to the *Multi-Terminal Monitor (MTM) Primer* or *OS/32 User's Manual* for additional information on the computer functions.

Section 1 - Introduction

1.3 Purpose and Objectives of Document

This document instructs users in the operation of the Communication Protocol Software. All the information necessary to send MCP and IFSM commands to the ACTS and receive telemetry data and event messages from the ACTS is provided.

Details of the protocol implementation used by the software are discussed only to strengthen the readers understanding of the software functions. Refer to the *HBR-LET Communication Protocol Software Maintenance Manual* for a detailed discussion of the protocol developed by GE and implemented on the Concurrent minicomputer.

1.4 Document Status and Schedule

Version 1.0 is the first publication of the Communication Protocol Software User's Guide. The HBR-LET was fully integrated and tested in May, 1991. Additional tests to characterize the terminal were continuing at the time of this publication.

The HBR-LET participated in ACTS System Test at the General Electric Astro Space Division in July, 1992. The software was successfully tested with the Communication Bus Simulator (CBS) and the Commanding, Ranging, and Telemetry Module (CR&T).

The current version of software running on the Concurrent computer was developed using GE's CBS, which simulates the CR&T. There were no noticeable differences noted between the two different systems during testing.

1.5 Document Organization

This document consists of ten sections. Sections 1 and 2 introduce this document and other documents related to it. Section 3 summarizes the main capabilities, functions, and limitations of the Protocol Software. Initialization requirements to execute the software are discussed in Section 4. Section 5 outlines the start-up commands, normal and abnormal termination procedures, and the recovery procedure from abnormal termination. Section 6 describes the requirements of the MCP and IFSM command files and the Protocol Software Monitor. MCP and IFSM command file errors, protocol errors and synchronization are discussed in Section 7. Sections 8 and 9 include a list of abbreviations and acronyms used in this document and a glossary of special terms. Section 10 includes a description of menu commands and instructions for defining the user's terminal, a summary of the commands used to sign-on to the computer and create MCP and IFSM command files and a list of Event messages from the *CR&T/MCS Interface Specification* document. Use the C&PM Software Problem Report Form provided in the appendices to report errors and erroneous operation.

Section 2 - Related Documentation

2.0 RELATED DOCUMENTATION

2.1 Parent Document

None

2.2 Applicable Documents

1. *ACTS MCP Command List*, LeVine, P.J., General Electric Astro Division, CMD-2606530, 1988.
2. *ACTS MCP Programming and Constraints*, Beck, G., General Electric Astro Division, IDD-PAC-2598605, 1986.
3. *CR&T/MCS Interface Specifications*, Konrad, D., General Electric Astro Division, IS-C-3261328, 1989.
4. *Communication Protocol Software Maintenance Manual*, Reinhart R., NASA Lewis Research Center, to be published.
5. *Communication Protocol Software Test Plan*, Reinhart R., May B., Daugherty E., NASA Lewis Research Center, to be published.

2.3 Information Documents

The following document provides an overview of the HBR-LET Software system.

1. *A Software Control System for the ACTS High Burst Rate Link Evaluation Terminal*, NASA Technical Memorandum 105207, NASA Lewis Research Center, Reinhart, R. and Daugherty, E., December, 1991.

Refer to the respective editor reference manual for operating instructions.

2. *OS/32 EDIT User's Guide*, Concurrent Computer Corporation, 1986.
3. *MEDIT Users Guide*, Perkin Elmer Corporation, 1984.
4. *MicroEMACS Reference Manual*, Lawrence, D.M. and Straight, B., 1987.

Section 2 - Related Documentation

The following textbook provides an overview of the sliding window protocol used in the Communication Protocol Software.

5. *Computer Networks*, Tanenbaum, A., Englewood Cliffs, Prentice Hall, 1981.

Section 3 - Overview of Purpose and Function

3.0 OVERVIEW OF PURPOSE AND FUNCTION

3.1 Protocol Software History and Overview

The protocol implemented in the Protocol Software on the Concurrent 3205 minicomputer was initially designed and developed by GE for a Hewlett Packard (HP) 1000 series computer running the RTE-A operating system and a DEC VAX computer running the VMS operating system. Software did not exist for the Concurrent computer and therefore was developed at the NASA Lewis Research Center according to the protocol specifications specified by GE.

There are two major functions performed by the Communication Protocol Software. First, it enables experimenters to send MCP and IFSM commands to the ACTS spacecraft via GE's CR&T. These commands control and configure the satellite to a desired configuration for a variety of applications. Second, it receives telemetry data from the ACTS and event messages generated by the CR&T.

Two RS-232 serial channels provide a medium for full duplex communication between the Concurrent 3205 and GE's CR&T. One channel is responsible for sending data whereas the other is responsible for receiving data. Synchronization and link monitoring are built into the protocol. The Protocol Software Monitor discussed in subsequent sections of this document, allows users to view the activity on both links by displaying the number and types of packets transmitted and received on the respective links. Refer to the *HBR-LET Communications Protocol Software Maintenance Manual* for additional information on the sending and receiving protocol implementation and format.

3.2 MCP and IFSM Command Files

The Protocol Software enables users to transmit high rate MCP commands and IFSM commands to the ACTS via GE's CR&T. High rate MCP commands provide remote control of traveling wave tube amplifiers, receivers, and other components of various transponders on board the ACTS. The IFSM commands consists of configuration and memory load commands that alter the state of the Digital Control Unit (DCU). The DCU which controls the IFSM, provides various communication paths through the IFSM. Refer to the *ACTS MCP Command List* and *ACTS MCP Programming and Constraints* documents for additional information on both the MCP and IFSM commands and technical format.

Develop MCP and IFSM commands according to the format specified in the above documents in ASCII text files using text editors on the

Section 3 - Overview of Purpose and Function

Concurrent computer or any PC word processor. MCP and IFSM commands transmitted to the ACTS from the LET ground station will be routed to the CR&T for destination verification and command validity. The Protocol Software verifies command syntax and command length only.

Users are responsible for creating and maintaining MCP and IFSM command files in a private account on the computer system. The Protocol Software retrieves command files from an account on the computer system and transmits them to the CR&T. The command file contains the desired commands and comments. Contact the Concurrent computer system administrator to gain access to an account on the system.

3.3 Event and Telemetry Messages

There are two types of event messages described in Appendix C; broadcast messages and station specific messages. Broadcast event messages indicate the current status of the CR&T. Station specific event messages are sent by the CR&T in response to commands received from a particular station. These messages generally contain information regarding the status of MCP or IFSM command packets sent to the CR&T.

In addition to event messages, all stations on the communication network receive telemetry data from the ACTS via GE's CR&T. The telemetry data contains information concerning the Communication Electronics Package on board the ACTS. TWTA current levels, voltage levels, temperature levels and other information concerning the bus is provided. Currently, the telemetry data received from the CR&T is verified to insure the integrity of the communication link, and then discarded.

3.4 Protocol Software Test Procedure

A test procedure has been developed to verify the operation of the Protocol Software. The *HBR-LET Communication Protocol Test Plan* provides a step-by-step procedure to test telemetry reception, numeric commanding, event message processing, telemetry error handling, and command error handling.

Log files generated by the test software records the data received by the C&PM computer and the responses of the C&PM computer to the various packets received. Refer to the *HBR-LET Protocol Software Test Plan* for specific details concerning each independent test. Run the Protocol Software test to verify the operation of the Protocol Software or to identify problems if errors are suspected.

Section 3 - Overview of Purpose and Function

GE's CBS was used to develop the test procedure described in the *HBR-LET Communication Protocol Software Test Plan*. As future testing with GE's CR&T occurs, modifications will be made to the test plan if deemed necessary. The test plan was designed to be applicable to both the CBS and CR&T. The plan tests for both normal operation and error conditions of the Protocol Software. Error forced in the data at known positions tests the error recovery capabilities of the software. All forced errors in the test plan are generated by the Concurrent computer, independent of the receiving node. The Protocol Software developers will verify the operation of the Protocol Software with the CR&T before making it available to users.

3.5 Restrictions and Limitations

The Protocol Software constantly receives telemetry data from the CR&T while it is functioning, and therefore is active at all times the software is executing. Although the Protocol Software is designed to minimally impact the computer system, running multiple programs in addition to the Protocol Software may result in reduced performance (in terms of execution time) of the other programs due to processor limitations.

Terminate the Protocol Software when it is not needed to avoid impacting other applications concurrently running. The software can be repetitively started and terminated from the C&PM Main Menu.

4.0 INSTALLATION AND INITIALIZATION

4.1 Initiation Commands

Three terminals are used to initialize, operate and maintain the Communication Protocol Software; a user's terminal, a programmer's terminal and the system console. The user's terminal serves as the primary user interface to the Protocol Software and other C&PM software applications. All Protocol Software functions including initializing the system, monitoring the communication links, and sending command files to the CR&T are controlled from the user's terminal by making the appropriate menu selections from the C&PM Main Menu.

The programmer's terminal provides access to the computer system via a user's account under MTM. Use the programmer's terminal to sign-on to the computer system and to create MCP and IFSM command files using the text editors installed on the system. The user's terminal does not provide access to the computer system other than for specific C&PM software applications.

The system console provides the user with greater control of the computer system. Use the system console to recover from catastrophic errors when they occur. Refer to Section 7 for information on error messages and error recovery.

Execute the Protocol Software from the user's terminal using the C&PM Main Menu. Appendix A describes the C&PM menu commands used throughout the Protocol Software. The procedures for selecting a menu item, inputting data to a menu and navigating through the menu system are described. The menu commands are the same for all menus and will not be repeated each time they occur in this document.

The user terminal serial communication port connection on the computer is defined in the first line of the Protocol Software menu program. Although a dedicated port has been reserved, the port designation can be changed if necessary. Appendix B contains a list of the Protocol Software menu programs and a procedure for redefining the user's terminal. Use the programmer's terminal to modify the Protocol menu programs.

Section 4 - Installation and Initialization

4.2 Equipment Requirements and Set-up

The Protocol Software resides on a Concurrent Corporation 3205 minicomputer utilizing Concurrent's OS/32 operating system. The Concurrent computer has a Multi-Terminal Monitor (MTM) in addition to the operating system, which serves as the interface between the user and the OS/32 operating system. All programs do not run under the control of MTM. The Protocol Software does not run under MTM, and therefore can only be executed from the user's terminal described in Section 4.1.

Two RS-232 serial communication ports of the Concurrent 3205 minicomputer are utilized to communicate with GE's CR&T. One channel is dedicated to transmitting data to the CR&T, and the other channel dedicated to receiving data from the CR&T. Each cable must be connected to the proper port for the system to function properly. Failure to meet this requirement will result in the inability to install or execute the Protocol Software. Refer to the *HBR-LET Communication Protocol Software Maintenance Manual* for a description of the communication port assignments and a general description of the hardware set-up. This requirement should be completed by the Software Manager or someone knowledgeable of the computer hardware configuration. Report any hardware configuration problems to the C&PM Software Manager, by completing the upper half of the CPMPR form provided in Appendix D.

An in-house developed menu driver utilized by the software requires a WYSE 50 or compatible terminal for best operation. The type of terminal used for menu display is indicated in the first record of the Protocol Software menu program. Refer to Appendix B for a description of the user's terminal definition and a list of the menu programs associated with the Protocol Software.

4.3 MCP Command File Names

Filenames on the Concurrent computer will consist of a volume, file name, extension, and account number employing the following format:

```
M1:-----./###
```

				account number
				filename extension
				filename
				user volume

User volume Two volumes on the Concurrent 3205 computer are independently utilized by the OS/32 operating system and individual user applications respectively. All MCP command data files will be located on the user volume, M1.

Filename All filenames on the Concurrent 3205 computer consist of one to eight alphanumeric characters with the first being alphabetic. The Protocol Software uses only the first four characters of the data file name. Users are permitted to use additional characters in the name, but note that the Protocol Software will omit extra characters when referring to the file. The protocol standard allows for a six character file name. The Protocol Software uses the additional characters to properly identify the data files sent to the CR&T. The user can select any name for the MCP or IFSM command data file.

Extension	One to three alphanumeric characters indicating an extension to the filename. File name extensions are permitted, but will be disregarded by the Protocol Software when referring to the file.
-----------	--

Account number A dedicated user account on the computer system. User account numbers range from 1 to 254. Contact the system administrator for proper access to an account on the computer system.

Section 4 - Installation and Initialization

4.4 Loading System Programs and System Requirements

This document assumes that the Concurrent computer has been successfully booted and the C&PM Software installed and running. If the C&PM Software is not running, type the following command at the system console prompt:

> CPM

The computer system will respond with the following message indicating that the C&PM Software is ready.

C&PM Software System Successfully Loaded and Started

MCP and IFSM command files must exist in a user's private account before they can be sent to the CR&T. The Protocol Software does not provide a means to create nor edit command files. Create command files using the programmer's terminal before executing the Protocol Software. Contact the system administrator to obtain access to a private computer account to create command files.

5.0 STARTUP AND TERMINATION

5.1 Pre-initialization Procedures

The Protocol Software does not run under the control of MTM. If both the Protocol Software and MTM are executing simultaneously, the communication ports connected to GE's CR&T must be removed from MTM. Remove the communication port by typing the following commands at the system console prompt:

```
> REMMTMLET <cr>
```

Failure to remove the communication ports from MTM will result in the inability to execute the Protocol Software. Display the logical unit assignment of the MTM task at the system console to verify that the communication ports are not assigned to the MTM task. Enter the following commands:

```
> T(ask) .MTM  
> D(isplay) L(ogical Units)
```

The computer will respond with a list of the logical unit assignments and their associated device. Verify that CRT6: and CRT7: are not on the list. If either device appears on the list, repeat the above procedure paying close attention to the command syntax. Notify the C&PM Software Manager if errors persist via a CPMPR form provided in Appendix D.

Note: This pre-initialization step should be completed by the C&PM Software Manager or someone knowledgeable of the computer system when installing the C&PM Software system. This section is included for completeness.

Section 5 - Startup and Termination

5.2 Start-up Commands

Select the **Execute Protocol Software** option from the C&PM Main Menu to load and initialize the Protocol Software. The software will respond with several messages. Provided errors do not exist, the following messages will appear at the user's terminal;

"Opening and Loading Protocol Software Files"

"Software Initialization Complete"

Once the software has been successfully installed and initialized, the C&PM Main Menu will be redisplayed to the Main Menu. Verify that the Protocol Software is properly loaded by viewing the Protocol Monitor. The Protocol Monitor will display several parameters associated with the various packet types sent and received by the Concurrent computer and the CR&T. Note that the Concurrent 'Send Initiate' counter increments approximately every 15 seconds indicating that it is trying to initialize the communication link with the CR&T. After the CR&T sends a 'Send Initiate' packet, the channel will be initialized and ready for data transmission.

Any errors that occur during installation will result in appropriate messages displayed at the user's terminal. If errors occur, refer to Section 7 for error recovery procedures. Use the Protocol Monitor to verify that the communication link is UP before attempting to send command files to the CR&T.

5.3 Normal Termination Procedure

The Protocol Software runs continuously, ready to receive telemetry data or event messages. Terminate the Protocol Software by selecting the **Cancel Program** option from the C&PM Main Menu. The Cancel Program menu will appear, similar to the Main Menu. Select the Protocol Software option to terminate the Protocol Software and return to the Main Menu. If the **Cancel Program** is selected inadvertently, press Ctrl-C to return to the Main Menu without altering program execution.

5.4 Abnormal Termination Procedure

In the event the Protocol Software cannot be terminated from the user's terminal, use the system console to abort program execution. Enter the following command at the system console to terminate the Protocol Software.

> PROABORT

This command will cancel all the programs associated with the Protocol Software and return the Main Menu to the user's terminal.

This command will also terminate the program that sends command files to the CR&T. If the command file program (option - Send MCP/IFSM File) is interrupted, verify that the commands were received by the CR&T. Resend the commands if necessary to assure they are received by the CR&T.

5.5 Abnormal Restart Procedure

Reinitialize the Protocol Software after a failure by following the normal startup commands. Using the Protocol Monitor, verify that the communication link is operational by observing that the link is UP. If an error condition exists after several initialization packets are sent, submit a CPMPR form to the C&PM Software Manager.

Section 6 - Functions and their Operations

6.0 FUNCTIONS AND THEIR OPERATIONS

6.1 MCP and IFSM Command Files

MCP and IFSM command files enable users to specify multiple or single commands to send to the ACTS spacecraft. The data files provide a convenient and efficient method of documenting the commands sent to the spacecraft as well as providing users a way to prepare commands before using the Protocol Software.

The MCP and IFSM command files must exist in a user account on the Concurrent system before accessing the Protocol Software. Create command files using any text editor or word processor capable of reading and writing an ASCII text file.

Use the programmer's terminal to create command files on the Concurrent computer. Three text editors; EDIT32, EMACS, and MEDIT are currently installed on the computer system. Refer to the respective user's manual for operating instructions on the various editors.

Note: Errors have occurred in the past using the EMACS editor to create files due to control characters placed within the document. If EMACS is used to create files, save the file using one of the other editors on the system. EDIT32 and MEDIT do not attach control characters to their documents.

Save word processing files as "ASCII text files" to eliminate control characters in the document. Transfer files created using word processors to the Concurrent computer before using the Protocol Software.

6.1.1 File Syntax

The *ACTS MCP Command List* lists and describes the valid MCP commands. The *ACTS MCP Programming and Constraints* document describes the format of the IFSM commands. The list of MCP commands includes the hexadecimal code, type, description, mnemonic and telemetry information for each command. The Protocol Software will only read the hexadecimal code for each command from the data file. All other information concerning a command must be declared a comment if included in the file. Figure 6-1 illustrates a sample MCP Command File.

```

;      MCP Command File
;
50AF          ; TWTA NO.1 ON
9D62 916E 9966 ; TWTA NO.2 HELIX PROTECT ENABLE,ON,UV/OC ENABLE
#
; comment line
; comment line

```

Figure 6-1 MCP Command File

Although IFSM commands are developed as a binary string, they too must be specified as a hexadecimal number. Manually, convert the binary string to its hexadecimal equivalent and enter its result as the valid command. Place the binary string within the file preceded by a semi-colon representing a comment. Use the binary string to document and verify the command in the event of errors.

Section 6 - Functions and their Operations

Figure 6-2 illustrates the format of an IFSM command file. Note the conversion of the binary string to its hexadecimal equivalent, and the comments used.

```
;      IFSM Command File
;
; Memory Load 0 word ID=0, op bit valid, switch 1&2 open
3000  ; 00 1 1/ 0000/0000/00 00
; Memory Load 1 word ID=0, op bit valid, switch 10 closed
4040  ; 01 0 0/ 0000/0100/00 00
#
; comment line
; comment line
```

Figure 6-2 IFSM Memory Load Command File

MCP and IFSM commands must be valid commands from the *ACTS MCP Command List* or the *ACTS MCP Programming and Constraints* documents. Each valid command must consist of four upper case hexadecimal characters. Individual or multiple commands per line are permitted, provided they do not exceed eighty columns. Use a space as a delimiter for multiple commands on one line. A semi-colon (;) indicates a comment statement. Comments can encompass an entire line or a part of line. Everything in a record after a semi-colon is interpreted as a comment, including valid MCP and IFSM commands.

Place a pound sign (#) after the final MCP or IFSM command. Additional text may follow the pound sign provided the text is preceded with a semi-colon.

The Protocol Software will verify the syntax of the data file before transmitting it to the CR&T. If a syntax error exist, the file will not be transmitted and the user notified with appropriate error messages. Refer to Section 7 for additional information and recovery procedures from syntax and other command file errors.

6.1.2 File Size

MCP and IFSM command files can contain up to 5000 four character commands. The protocol standard allows a maximum of 100 four character commands per data packet transmitted to the CR&T from the Protocol Software. The Protocol Software will divide the command file into the appropriate number of data packets to send to the CR&T based on the number of commands in the file. Data packet file names are encoded using the command filename, the account number, and the current packet number. Use the information in the filename created by the Protocol Software to identify the location of errors in the command file, if they occur.

Section 6 - Functions and their Operations

The protocol standard limits the command filename to six characters. Although the Protocol Software uses the computer system filename restrictions (see Section 4.3), the filename transmitted to the CR&T may differ from the user filename. The Protocol Software creates the filename as follows:

1. The first four characters of the Protocol filename name are the first four characters of the user filename.
2. The fifth character is the encoded account number of the file. The account number is the last character of the actual user account number.
3. The sixth character is the encoded packet number. The packet number is the last character of the actual packet number.

Table 6-1 lists various examples to illustrate the above procedure.

User Filename	Accnt Num	Number of commands	Number of Packets	Accnt Num	Protocol File; Num, Name, Command		
DEMO.XXX	5	99	1	5	1	DEMO51	99
DEMO2	4	98	1	4	1	DEMO41	98
TEST1	34	101	2	4	1 2	TEST41 TEST42	100 1
TEST	123	178	2	3	1 2	TEST31 TEST32	100 78
TEST.TXT	147	1001	11	7	1 . . 9 10 11	TEST71 . . TEST79 TEST70 TEST71	100 . . 100 100 1

Table 6-1 MCP Command Protocol Filename Generation

Note: The Protocol Software will use the first four characters of the user filename. Excess characters and the filename extension will be disregarded. This condition will not generate an error message from the Protocol Software.

6.3 Sending MCP and IFSM Command Files to the CR&T

Once an MCP or IFSM command file is created, it is ready to send to the CR&T. Select the **Send MCP/IFSM Command File** option from the C&PM Main Menu (user terminal) to execute the software used to perform the data transmission function. Perform the following commands to successfully transmit a command file to the CR&T. Computer prompts are illustrated in this text in bold. Press return after responding to each prompt.

- 1) **Enter filename:**
Enter the command filename at the prompt including the extension.
- 2) **Enter Account Number:**
Enter the account number where the command file resides. The software will syntax check the filename and verify that the file exists in the specified account.
- 3) **Enter Command Destination:**
Enter the command destination for the entire command file. All commands in a single file must go to a single destination. The LET has two valid destinations available; The **MCP Command Enable (CTP)** and the **IF Switch Matrix Enable**. The syntax check on the file contents will occur at this time. Correct any errors that exist, shown by appropriate error messages, and repeat the above procedure.
- 4) **Do you want to send another file with this set(Y/N)?**
More than one command file can be sent to the CR&T at a time. Indicate whether to send multiple files or a single file within the current group. Multiple files will be divided among separate data packets by the software. A limit of eight files or 5000 commands (whichever comes first) is imposed by the Protocol Software. If the file contents exceed the limit, the software will issue a prompt to determine whether to transmit the portion of the data packet loaded thus far to the CR&T or abort the session.

Section 6 - Functions and their Operations

- 4a) Responding No (N) to the prompt in step 4 will command the software to send the specified files to the CR&T. The Protocol Monitor will display automatically. After a short pause (5 seconds) the C&PM Command Counter will increment indicating that the packet(s) have been transmitted to the CR&T. Note that the HPA600 responds with a positive or negative response packet (ACK or NAK), and the appropriate counter increments. All event messages are displayed on the Protocol Monitor as they occur. Verify that all files were properly received by the CR&T by noting the data packet names specified in the event messages.

To exit the Protocol Monitor after all packets are sent, press the return key until a prompt appears indicating to exit or resume. Press R to Return to the Protocol Software or C to Continue monitoring.

- 4b) Responding Yes (Y) will repeat steps 1-4 without sending the commands specified thus far, provided another file will not exceed the data packet limit.
- 5) **Do you want to send another file (Y/N)?**
This prompt appears after exiting the Protocol Monitor. Indicate whether to send additional files to the CR&T.
- 5a) Responding Yes (Y) will repeat steps 1-5.
- 5b) Responding No (N) will terminate the MCP/IFSM command file program and return the C&PM Main Menu to the user terminal.

6.4 Protocol Software Monitor

Telemetry reception, packet processing, and synchronization are all performed by the software without displaying output to the user's terminal. A monitor program enables users to observe the activity on each link of the Protocol Software. Figure 6-3 illustrates the menu screen of the Protocol Monitor. A counter for each parameter is updated on the screen when an action occurs. The time is provided to monitor the time between data packet transmission and response packet reception.

Control and Performance Monitoring Protocol Software Monitor			
HP A600 Send Initiate	2	C&PM Acknowledge Counter	135
HP A600 Telemetry/Event	134	C&PM NAK Counter	1
C&PM Send Initiate	3	HP A600 Acknowledge Counter	20
C&PM MCP Command	17	HP A600 NAK Counter	0
Event Messages Received from the HP A600			
TWT A92 list received by A600			
TWT A92 list verified by A600			
Current Time 12:34:56			

Figure 6-3 Protocol Software Monitor

Section 6 - Functions and their Operations

The parameters of Figure 6-3 represent the number of packets that are transmitted and received by the C&PM Protocol Software and GE's HP A600 CR&T. The appropriate counter will increment once for each packet transmitted or received by the Protocol Software or HP A600, respectively.

Note: All counters will reset themselves to zero at approximately 50000 for menu clarity and to avoid possible overflow.

Telemetry packets and event messages are counted together in the HP A600 Telemetry/Event counter. Event messages will appear on the Monitor when they occur. The Protocol Monitor will update the event message display as new messages are received. The monitor will automatically appear after sending MCP or IFSM command files to the CR&T to allow users to verify that the commands were received and verified by the CR&T. Refer to Appendix C for a list of the event messages and a description of each.

The CR&T automatically sends telemetry data to all stations on the network. Telemetry data received by the Protocol Software is not displayed by the Protocol Monitor. Currently, the HBR-LET does not use the telemetry data and therefore it is not displayed.

6.5 Event Messages

Event messages are issued by the CR&T and received by the Protocol Software. Event messages contain information concerning the CR&T status or information about command files sent to the CR&T from the Concurrent computer. Event messages occur randomly and each have different lengths depending on the particular message. Use the Protocol Monitor to view event messages after sending commands to the CR&T.

Individual event messages are described in the *CR&T/MCS Interface Specification*. A portion of that document has been reproduced in Appendix C for the user's convenience. Refer to Appendix C for additional information on specific event messages encountered.

7.0 ERROR MESSAGES AND RECOVERY PROCEDURES

7.1 MCP and IFSM Command File Syntax Errors

The Protocol Software will verify the syntax of all commands in the MCP and IFSM command files. MCP and IFSM commands must consist of four upper case hexadecimal characters 0 through F. If a non hexadecimal character is detected, the Protocol Software will display the character(s) in error at the user's terminal. Any MCP or IFSM command that has other than four characters will also be considered an error. The software will specify the number of extra characters when this occurs. Figure 7-1 illustrates the two types of errors discussed above. Comments will not be checked and can contain any type of character.

```

;      MCP Command File
;
50AG          ; TWTA NO.1 ON
9D62 916E4    ; TWTA NO.2 HELIX PROTECT ENABLE, ON
#
; comment line
; comment line

```

Figure 7-1 MCP Command File with errors

Figure 7-1 is similar to Figure 6-1. Note that the first command is now 50AG instead of 50AF. The character G in the command will cause a syntax error because G is not a hexadecimal character. In the next line of commands, the second command 916E4 should be 916E. The syntax check will detect extra or omitted characters (extra in Figure 7-1) and flag the error condition.

Use one of the text editors on the Concurrent computer to edit command files and recover from syntax errors. Locate the invalid character(s) in the command file and make the appropriate modifications to correct the error. The Protocol Software will recheck the command file before sending it to the CR&T. Repeat the above procedure if these types of errors persist.

7.2 Protocol Errors

Section 7 - Error Messages and Recovery Procedures

7.2 Protocol Errors

Once an MCP or IFSM command file has been properly encoded according to the *CR&T/MCS Interface Specification*, it is sent to the CR&T. The CR&T can acknowledge the packet in one of three ways. It can send a positive acknowledgement (ACK), a negative acknowledgement (NAK) or not acknowledge it at all (time out). A positive acknowledgement indicates successful transmission of the packet. A negative acknowledgement results when there are protocol errors in the transmission detected by the CR&T. Failure to send a response packet of some type represents that the CR&T did not send a response packet or the Concurrent failed to receive the response, either of which is an error condition. The Protocol Software will attempt to recover from transmission errors by sending the data packet again. Data packets not acknowledged by the CR&T will not return event messages.

If a data packet does not receive a positive acknowledgement after three consecutive tries, the Protocol Software will abort the process and reinitialize the communication link. Users must repeat the procedure to send a command file to the CR&T if this occurs. If this type of error persists after several tries, notify the C&PM Software Manager. This indicates an error in the communication link or the protocol software at either the sending or receiving node.

7.3 MCP Command Errors

An MCP command data packet received by the CR&T from the Concurrent computer may still contain errors. The CR&T will verify each command of the MCP file before sending it to the ACTS spacecraft. If the CR&T detects an invalid command, it will stop transmitting the commands to the ACTS, and send an event message back to the Protocol Software indicating the type of error that occurred. Refer to Appendix C for a list of possible event messages. Use the Protocol Monitor to view event messages after sending an MCP Command File. Figure 7-2 illustrates both a positive and negative event message. A positive event message is generated by the CR&T when all commands in the data file are valid.

a) Positive Event Message

TEST41 list received by A600
TEST41 list verified by A600

b) Negative Event Message

TEST31 Packet rejected, list contains unauthorized commands

Figure 7-2 Positive and Negative Event Messages

Note that the event message contains the filename generated by the Protocol Software which may be different from the user filename. Refer to Section 6.1.2 for an explanation of the protocol filename generation procedure. Positive event messages indicate that the command packet was received and that all the commands were valid. Negative event messages indicate that the command packet was received, but contained at least one invalid command. The CR&T will not continue to process a packet once an invalid command is detected. The user is responsible to determine the invalid command and correct the error.

Section 7 - Error Messages and Recovery Procedures

7.4 Synchronization

Both the sending and receiving node are required to send synchronization packets during periods of link inactivity. The Protocol Software will send synchronization packets to the CR&T to initialize the link and during times when no command packets are sent.

The CR&T will send synchronization packets to the Protocol Software when there are no event messages or telemetry data to transmit. If either node fails to send the synchronization packet at the required intervals, the communication link will become inoperative until reinitialized by both nodes.

Users can monitor the synchronization packets using the Protocol Monitor. The synchronization or initialization counter will increment each time a packet is sent or received. If the link fails for an extended period of time (approximately 1-2 minutes), notify the C&PM Software Manager, provided the respective protocol software is running at both the sending and receiving nodes.

8.0 ABBREVIATIONS AND ACRONYMS

All abbreviations are defined the first time they appear in this document. Reference the list of abbreviations and acronyms and their definition when using this manual.

ABBREVIATION	DEFINITION
ACK	Positive acknowledgement
ACTS	Advanced Communications Technology Satellite
C&PM	Control and Performance Monitoring
CBS	Communications Bus Simulator
COMSAT	Communications Satellite Corporation
CPMPR	Control and Performance monitoring Problem Report Form.
CR&T	Commanding, Ranging, and Telemetry Module
CTP	Command and Telemetry Processor
DEC	Digital Equipment Corporation
GE	General Electric
HBR-LET	High Burst Rate Link Evaluation Terminal
HP	Hewlett Packard
MCP	Multibeam Communication Package
MCS	Master Control Station
MTM	Multi-Terminal Monitor
NAK	Negative acknowledgement
NASA	National Aeronautics and Space Administration

Section 8 - Abbreviations and Acronyms

PROSA	Protocol Software Account, Volume M1, account number 5
RTE-A	Run-time executive, version A
SMAP	Software Management and Assurance Program
VAX	Virtual Addressing Extension
VMS	Virtual Memory System

9.0 GLOSSARY

event message - status or information messages of random packet sizes sent by the CR&T to receiving stations on the link.

MCP command - various control commands to configure the ACTS. Commands are used to control the Motor Drive Electronics, Intermediate Frequency Switch Matrix and the Baseband Processor.

response packet - the receiving node sends this type of packet to the sending node to indicate the status of the received packet. Response Packets can be positive or negative acknowledgements depending on the status. Negative acknowledgements result in retransmitting the original packet from the sending node until successful reception (ACK) or three consecutive attempts.

synchronization - both stations on the communication link are required to send special packets across the channel during periods of inactivity to assure that the channel is ready for the next transmission. The synchronization packets place the receiving nodes in a known state, ready for future transmissions.

telemetry packets - data received from the satellite and transmitted to all stations on the network. These packets are transmitted at a constant rate and packet size.

Appendix A - Common Menu Functions and Features

10.0 APPENDICES

Appendix A

Common Menu Functions and Features

There are several functions common to all menus found in the C&PM Subsystem Protocol Software. These functions are presented in detail and later summarized for easy reference. The key stroke and resulting action are both listed in the summary.

Data can be input to a menu using a combination of two ways. The first is to type the desired data in a format identical to that given in the option field for the particular input. Numerical values are generally typed in and do not have any special format. Both decimal and integer numerical values are accepted. It is best to clear the input field before entering any typed input. Clear the input field by either pressing the space bar over each character or by pressing the DELETE key, which will clear the entire field.

The second method of entering data is by selecting an element of the option field. To select an option, first move the cursor into the option field by pressing the HOME key. Placing the cursor on the same line as the desired option and pressing the ENTER key will place a copy of the option and the cursor into the input field. Repeat the above steps until all selections are made. Once inside the input field, press ENTER a second time to direct the system to accept the input.

If a mistake is detected after the system has accepted an input, the user can return to the previous menu by pressing CTRL-C. However, this will not reverse the previous command. Be certain the current menu has not been altered in any way prior to pressing CTRL-C. If the menu has been altered, pressing CTRL-C is equivalent to pressing ENTER. CTRL-C can only be used before any change is made in the current menu.

Some menus contain more than one input field. The above procedures can be followed for each input field. Use the arrow keys or the tab key to move from one field to another, and the arrow keys to move among the various options in the option field.

Note: CAPS LOCK key must be on during all menu functions to ensure proper menu operation.

Appendix A - Common Menu Functions and Features

Summary of Commands

- ENTER: Once the input field contains a selection, this command will instruct the system to accept the input.
- HOME: Toggle the cursor between the input and option fields.
- DELETE: Clears the entire input field that the cursor currently resides in.
- CTRL-C: Allows the user to 'back out' of the menu system one menu each time it is pressed. Equivalent to pressing ENTER if menu is altered prior to using this function.
- ARROW KEYS: Used to move among the options and input fields.
- TAB: Used to move among the input fields.

Appendix C

Event Messages

Appendix A of the *CR&T/MCS Interface Specification* document is included in this guide for the users convenience. The *CR&T/MCS Interface Specification* document provides information on various event message formats and command types (Low Rate/High Rate). The reader is encouraged to consult the *CR&T/MCS Interface Specification* document for additional information. The following is a list of possible event messages.

These types of messages shall be broadcast to all stations each time they occur.

Event Message	Explanation
Bad FCD command counter status	The FCD error status bit in telemetry is set.
CR&T awaiting command packets	The CR&T is able to accept high-rate command packets from all stations. This message is typically transmitted following CR&T module initialization and upon clearing an error.
Resynchronizing the FCD counter	The CR&T is synchronizing the high-rate command counter with that received in telemetry. This will occur during initialization and in response to a directive from the Flight System Monitor and Control.
Beginning TLM	The CR&T has begun to receive telemetry from the spacecraft.
TLM Lost	The CR&T is no longer receiving telemetry from the spacecraft.

Appendix C - Event Messages

This group of messages contain a file name in the first six bytes of the message. These messages shall only be transmitted to the source station.

Event Message	Explanation
FILENAME - Packet rejected, list has more than 100 command words.	The command packet contains more than 100 command words and was therefore rejected by the CR&T module.
FILENAME - Packet rejected, list has more than 10 discrete.	The command packet contains more than 10 discrete and was therefore rejected by the CR&T module.
FILENAME - Packet rejected, CR&T is in local mode.	The command packet was received by the CR&T module while the CR&T module was in the local mode.
FILENAME - Command list rejected by CR&T.	The command packet was received by the CR&T module, but high-rate commanding has been disabled by the CR&T software.
FILENAME - List received by the CR&T.	The CR&T module received the command packet.
FILENAME - Packet rejected, Packet count not equal to number of commands received.	The packet command count differs from the actual number of commands received in the packet.
FILENAME - Packet rejected, list contains unauthorized commands.	The command list received contains one or more protected commands which have not been authorized.

Appendix C - Event Messages

Event Message	Explanation
FILENAME - List verified by CR&T.	The CR&T module has verified that the command list has been accepted by the spacecraft FCD.
FILENAME - List verification failed on command word NNN.	The FCD counter has not updated sufficiently within the allowable time window. NNN is the number of the first command word in the list that was not accepted.
FILENAME - Successful loopback verification.	Commands received at the demodulator matched the commands sent to the modulator.

Appendix C - Event Messages

Event Message	Explanation
FILENAME - Loopback verification failed on command word NNN.	Commands received from the demodulator did not match the commands sent to the modulator. NNN in the message will appear as the number (i.e. position in the list) of the command word that caused the failure.
FILENAME - High-rate modulator status error detected.	The modulator has reported an internal error. The status of the modulator is observed following the transmission of a high-rate command list and a modulator reset has been initiated by the CR&T module.
FILENAME - High-rate demodulator status error detected.	The demodulator has reported an internal error. The demodulator status will only be checked if command loopback has been selected.
FILENAME - Packet rejected due to station lockout.	The CR&T has locked out the source station by request of the FSM&C. The CR&T will not accept any packets from that station.

Appendix D - C&PM Software Problem Report Form

Appendix D

HBR-LET Control and Performance Monitor Software Problem Report

Problems or errors may be encountered while executing the Protocol Software that have not been described within this document. The user may be able to correct these errors by following the error recovery procedures discussed in Section 7. If error recovery is not possible, complete the **upper** half of the CPMPR form and submit it to the C&PM Software System Manager.

Recording new or unusual errors encountered while operating the Protocol Software will assist the software developers in improving the operation of the software and updating the Protocol Software User's Guide. A copy of the C&PM Software Problem Report form is provided in Figure D-1. Submit additional pages if additional space is needed.

Return the completed CPMPR form to:

Mr. Edward J. Petrik
NASA Lewis Research Center
Mail Stop 54-8
21000 Brookpark Road
Cleveland, Ohio 44135

Appendix D - C&PM Software Problem Report Form

HBR-LET Control and Performance Monitor Software Problem Report		
Name: _____	Date: _____	
Address: _____	Organization: _____	
_____	Phone: _____	
C&PM Software Application Name: _____		
Feature / Problem Description: (Include sequence number and/or instrument)		

Error Messages: _____		

Target Completion Date: _____		
Priority: High _____	Medium _____	Low _____

Cause of Problem / Action: _____	

Name: _____	
Date Corrected: _____	
CPMPR Number: _____	

Figure D-1 HBR-LET Control and Performance Monitor Software Problem Report

Appendix E

Concurrent 3205 Command Summary

Appendix E provides a quick reference to assist those user's not fully knowledgeable of the available commands on the Concurrent 3205 minicomputer. This is only a summary of the frequently used commands. The user is urged to consult the MTM Primer User's Guide for further information on the following commands. The full name of the commands are given. Only the characters outside the parentheses need be entered at the user terminal.

SIGNON Enables a user to access a private account. To sign on to an account, enter the following:

S(SIGNON) USER ID,ACCOUNT NUMBER,PASSWORD

The user id is a user defined, one to eight character name. The account number and password are previously established by the system administrator for a given account. If this information is required notify the C&PM Software manager.

SIGNOFF Ends a user session.

SIGNOFF

DISPLAY Displays Files in the user's account to the terminal.
FILES Outputs each filename and additional information identifying each file. Specific files can be displayed by the use of wildcards (-) when specifying filenames. Several examples are provided:

D(DISPLAY) F(ILES) Displays all files in account

D F, -.TDF Displays all files with extension .TDF

D F, EXAMPLE.- Displays all files with the name EXAMPLE regardless of the extension.

Appendix E - Concurrent Command Summary

COPYA Used to make a copy of a file in a private account. Ensure that the name of the file to be created does not currently exist in the account before executing the copy command. The copy command will over write the existing file.

COPYA NAME.EXTENSION,NEW_NAME.EXTENSION

RENAME Changes the name of an existing file in a user's account.

REN(AME) NAME.EXTENSION,NEW_NAME.EXTENSION

DELETE Permanently removes a file from a private account. The user is advised to exercise caution when deleting files in the account. Files removed from an account cannot be recovered.

DEL(ETE) NAME.EXTENSION

EDIT32 Line text editor available on the Concurrent computer. Use the line editor to create and modify MCP and IFSM command files. This editor does not place control characters into a document.

EDIT NAME.EXTENSION

Refer to the EDIT32 user's guide for command instructions.

MEDIT Screen text editor available on the Concurrent computer. Use the screen editor to create and modify MCP and IFSM command files. This editor does not place control characters into a document.

M(EDIT) NAME.EXTENSION

Refer to the MEDIT user's guide for command instructions.

EMACS Screen text editor available on the Concurrent computer. Use the screen editor to create and modify MCP and IFSM command files. This editor **places** control characters into a document. Save the document using one of the other editors described above to remove all control characters from the document.

E(MACS) NAME.EXTENSION

Refer to the EMACS user's guide for command instructions.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE March 1993		3. REPORT TYPE AND DATES COVERED Final Contractor Report
4. TITLE AND SUBTITLE Advanced Communications Technology Satellite High Burst Rate Link Evaluation Terminal Communication Protocol Software User's Guide Version 1.0			5. FUNDING NUMBERS WU-679-50-0A C-NAS3-25776	
6. AUTHOR(S) Richard C. Reinhart				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Analex Corporation 3001 Aerospace Parkway Brook Park, Ohio 44142-1003			8. PERFORMING ORGANIZATION REPORT NUMBER E-7657	
9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA CR-189162	
11. SUPPLEMENTARY NOTES Project Manager, Ernie W. Spisz, ACTS Project Office, (216) 433-3540.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified - Unlimited Subject Category 61			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The Communication Protocol Software was developed at the NASA Lewis Research Center to support the Advanced Communications Technology Satellite High Burst Rate Link Evaluation Terminal (ACTS HBR-LET). The HBR-LET is an experimenters terminal to communicate with the ACTS for various experiments by government, university, and industry agencies. The Communication Protocol Software is one segment of the Control and Performance Monitor (C&PM) Software system of the HBR-LET. The Communication Protocol Software allows users to control and configure the Intermediate Frequency Switch Matrix (IFSM) on board the ACTS to yield a desired path through the spacecraft payload. Besides IFSM control, the C&PM Software system is also responsible for instrument control during HBR-LET experiments, uplink power control of the HBR-LET to demonstrate power augmentation during signal fade events, and data display. The Communication Protocol Software User's Guide, Version 1.0 (NASA CR-189162) outlines the commands and procedures to install and operate the Communication Protocol Software. Discussed in the document are configuration files used to control the IFSM, operator commands, and error recovery procedures. The Communication Protocol Software Maintenance Manual, Version 1.0 (NASA CR-189163, to be published) is a programmer's guide to the Communication Protocol Software. This manual details the current implementation of the software from a technical perspective. Included is an overview of the Communication Protocol Software, computer algorithms, format representations, and computer hardware configuration. The Communication Protocol Software Test Plan (NASA CR-189164, to be published) provides a step-by-step procedure to verify the operation of the software. Included in the Test Plan is command transmission, telemetry reception, error detection and error recovery procedures.				
14. SUBJECT TERMS ACTS; HBR-LET; Computer software; RS-232 protocol; Satellite ground station; IF switch matrix; Microwave switch mode (MSM)			15. NUMBER OF PAGES 45	
			16. PRICE CODE A03	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	